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CROTALARIA VIRGULTALIS AND ALLIES IN SOUTHERN AFRICA

by

R. M. POLHILL (KEW) and A. SCHREIBER

Zusammenfassung

Crotalaria virgultalis Burch. ex DC. bildet mit *C. spartioides* DC., *C. orientalis* Burt Davy ex Verdoorn, *C. allenii* Verdoorn und *C. pseudovirgultalis* Torre eine eigene Gruppe innerhalb der Sektion *Geniculatae* (POLHILL 1968). Diese Arten kommen nur in den trockeneren Teilen des südlichen Afrikas (auf Kalahari-Sanden) vor. Sie werden in vorliegender Arbeit auf ihre Eigenständigkeit, Variationsbreite und Bildung von Übergangsformen untersucht. In einem scatter diagram (fig. 1) wird gezeigt, daß Blättchenbreite und Blattstiellänge keine guten Merkmale für die Unterscheidung der Arten darstellen. Färbung und Zeichnung der Blüten eignen sich hierfür wesentlich besser. Die am Material beobachteten Kombinationen von Färbung und Zeichnung einzelner Blütenteile wird dargestellt. Zur Erkennung von Übergangsformen zwischen *C. virgultalis* und *C. spartioides* wurde ein score diagram (map 1) erstellt, das ausführlich diskutiert wird. *C. orientalis* und *C. allenii* werden auf ihre spezifische Eigenständigkeit untersucht: *C. orientalis* wird als Art aufrecht erhalten, *C. allenii* wird als Unterart zu *C. orientalis* gestellt. *C. pseudovirgultalis* wird in die Diskussion ebenfalls einbezogen, ihre Eigenständigkeit wird bestätigt. Ein Bestimmungsschlüssel, Aufzählung der Arten, Verbreitungskarte (map 2) und Liste der benützten Literatur sind der Arbeit beigegeben.

Crotalaria virgultalis Burch. ex DC., *C. spartioides* DC., *C. orientalis* Burt Davy ex Verdoorn, *C. allenii* Verdoorn and *C. pseudo-virgultalis* Torre belong to section *Geniculatae* (POLHILL 1968), in which they form a discrete group defined as follows: stems ribbed (neither terete nor winged), leaves unifoliolate (occasional leaf sometimes trifoliolate) and petals yellow or white (not blue). The group is virtually restricted to the area of Kalahari sands in the drier parts of southern Africa.

Traditionally *C. virgultalis* and *C. spartioides* have been differentiated by the leaflets, which are narrower (sometimes involute) and often on shorter petioles in *C. spartioides* (DE CANDOLLE, 1825; BENTHAM, 1843; HARVEY 1862; E.G. BAKER 1914; VERDOORN, 1928). The additional material now available shows the variation to be continuous. This is illustrated in the form of a scatter diagram in fig. 1. The mean length of petioles and the mean width of leaflets (unrolled where necessary) on the middle part of the stem have been plotted for each reasonably well collected herbarium specimen. No separation is apparent.

Dr. Leistner, National Herbarium, Pretoria, has seen the species growing in various places and drew our attention to differences in flower colour. Typically in *C. virgultalis* the standard is white with reddish lines outside (the red sometimes more diffused, particularly with age), the wings are bright yellow, and the keel paler with the beak speckled or suffused reddish brown to purple. Typically in *C. spartioides* the petals are all yellow (the keel paler), without darker markings, and usually the flowers are rather smaller. These differences are not constant, however, over a rather large part of the distribution area. The sort of variation that can occur may be indicated by examples of collections from the Aroab area of the Keetmanshoop District of South West Africa and from the Gordonia and Postmasburg Districts of South Africa.

Aroab area

Standard white, lined darker; tip of keel dark, the speckles partly fused (BLEISSNER 291).

Similar but red diffused on standard (GIESS, VOLK & BLEISSNER 7201).

Standard white, the veins dark or just finely dotted; beak of keel speckled to varying degrees (DE WINTER 3377).

Standard pale rose with faint reddish lines developed to varying degrees; keel finely and variably speckled (LEISTNER 1789). Standard probably pale, the veins dotted with minute spots; keel rather thinly speckled (ACOCKS 15585). Standard yellow, unlined; keel finely speckled (LEISTNER 1790).

Gordonia and Postmasburg Districts

Standard white with reddish lines; keel with purple tip (LEISTNER & JOYNT 2798).

Standard white with maroon lines, keel rusty red at tip, but specimens show markings developed to varying degrees; both species noted to be growing together (LEISTNER 1600).

Standard noted by collector as white with purple lines, keel with purple lines, but one duplicate (at Kew) with unmarked flowers (LEISTNER 2091).

Petals yellow; beak of keel speckled (LEISTNER 2172).

Similar, but keel only sometimes speckled (LEISTNER 2194).

Petals yellow, unmarked (LEISTNER 2074).

The varied combination and differing degrees of expression of these factors in intermediate plants could be the result of introgression. A simple hybrid index can be made by scoring two points for each character state typical of *C. virgultalis*, zero for each typical of *C. spartioides*, and one where the state is intermediate or inconstantly expressed. Five characters have been scored on the following basis:

1. Standard white = 2; yellow = 0.
2. Standard with reddish lines = 2; unlined = 0.
3. Keel marked darker = 2; unmarked = 0.
4. Keel 14-18 mm. long = 2; 13-14 mm. = 1; 11-13 mm. = 0.
5. Leaflets with mean width of more than 2,5 mm. = 2; 1,5-2,5 mm. = 1; less than 1,5 mm. = 0.

The scores are shown on map 1. Specimens in fruit or with insufficient data to score flower colours have been omitted (compare map 2). It will be seen that collections with 8-10 points, i.e. most features of *C. virgultalis*, or with 0-2 points, i.e. most features of *C. spartioides*, are most common on the periphery of the total distribution area. *C. spartioides* alone occurs in Botswana and adjacent parts of the NE. Cape Province. *C. virgultalis* alone occurs near the Vaal and upper reaches of the Orange River. Both occur in the Gordonia and Postmasburg Districts with intermediates of all sorts as noted above. In South West Africa the characteristics of *C. virgultalis*

predominate in the south and of *C. spartioides* further north, but specimens rarely look quite typical of either species and towards the south-east, in the Keetmanshoop District, the characteristics are very mixed. We have referred all material seen from the Gobabis, Windhoek and Rehoboth Districts to *C. spartioides*, but it is possible that plants approximating closer to *C. virgultalis* do occur. DINTER (1920) records two specimens of *C. virgultalis* which we have not seen - Gobabis to Oas, DINTER 2717 and Kalkfontein, DINTER 2717 a. Dr. Leistner reports that STEYN s.n. (Onderstepoort No. 8962) from Windhoek District, Otjimbondona, Farm No. 225, seems to him more like *C. virgultalis* than *C. spartioides*. Specimens from the border region along the lower reaches of the Orange River are all very imperfect, but seem to be of an intermediate type.

The intermediates seem to be of secondary origin. There is no evidence of a relatively uniform stock from which extremes might have diverged, nor of a simple cline across the range. On the contrary the features of *C. virgultalis* and *C. spartioides* are expressed in varying degrees where the ranges overlap suggesting a prolonged period of introgression. The ecological data on specimen labels is inadequate, but it seems possible that *C. virgultalis* in a restricted sense tends to occur on flats of loose sand, whereas true *C. spartioides* tends to occur on consolidated and fossil dunes. The intermediates are less restricted occupying a wide variety of sandy places, and are now more widespread than the parent species. This makes naming a little difficult. We have used the hybrid index scores, determining material with 8-10 points as *C. virgultalis*, 0-2 as *C. spartioides*, 7 and 3 as atypical and 4-6 as intermediates. We consider flower colour as the best indicator, but none of the factors (standard colour, standard markings, keel markings) seems more significant than the others; marked variation of flower colour is a good indicator of intermediates.

C. orientalis and *C. allenii*, described a century later (VERDOORN, 1928), occur north and north-east of *C. virgultalis* and *C. spartioides* (map 2). They differ from *C. virgultalis* and *C. spartioides* by the generally longer petioles (fig. 1), longer pedicels and by the glabrescence of the branches. The variation overlaps for each character, but a reasonable separation can be made on the combination of characters. The available information on flower

colour is inconclusive. Where noted in detail the standard is described as white inside, yellow lined reddish brown outside, and the keel is usually but not always marked darker at the tip, but a number of collectors just note the flowers as yellow or the standard as white. VERDOORN (1928) paired *C. orientalis* and *C. spartioides* with narrow leaflets and *C. allenii* and *C. virgultalis* with broader leaflets, but the flower colour, flower size and longer petioles suggest both *C. orientalis* and *C. allenii* are closer to *C. virgultalis*. Certain specimens of *C. orientalis* (LAM-BRECHT 33, LEACH & NOEL 207) have a few trifoliolate leaves and the markings of the flower are comparable with *C. flavicarinata* Bak. f., a related but less specialised species of the Okovango-Zambesi-Kafue basin, which is bushy with trifoliolate stipulate leaves. Similarities between *C. orientalis* and *C. spartioides*, particularly in the leaf shape, are probably due to convergence. *C. orientalis* and *C. allenii* could be reduced to subspecies of *C. virgultalis*, but as *C. orientalis* is liable to confusion with *C. spartioides* and as introgression makes the segregation of *C. virgultalis* and *C. spartioides* difficult, it seems preferable not to broaden the concept of *C. virgultalis* any further.

The leaves of *C. allenii* are usually larger than those of *C. orientalis* but there is some overlap and the most significant difference seems to be in the indumentum. *C. orientalis* is based principally on BURKE 338 from Rhenoster R. in the Orange Free State (ZEYHER 370, probably collected simultaneously and cited by BURTT DAVY (1932) as a syntype, is a poorer specimen). In the lectotype the ovaries are glabrescent, densely pubescent when young but quite glabrous by the fruiting stage. In collections from the Zeerust area of the Transvaal and adjoining parts of Botswana, the ovary is either glabrous or with sparse hairs shed at an early stage. No specimens from the more distant localities of the Waterberg District of the Transvaal and, coincidentally, the Waterberg area of South West Africa shows development of the fruit, but in flower they have densely hairy ovaries and the one specimen in fruit, CODD 8462, has glabrous pods. On somewhat limited evidence we characterise *C. orientalis* by glabrescence of the fruits, accepting considerable variation of the ovary indumentum. By contrast the fruits of *C. allenii* remain finely pubescent. The indumentum of the standard shows some correlation, being absent or sparse in *C. orientalis*, extensive in

C. allenii, but where ranges overlap in the Waterberg District of the Transvaal it is difficult to name flowering specimens with certainty. On available evidence we maintain *C. orientalis* distinct from *C. virgultalis* and include *C. allenii* as a subspecies, but further collections might well suggest some alternative arrangement. More information from the NW. Transvaal would be particularly welcome.

The last species of the group to be described is *C. pseudovirgultalis* Torre, known only from the Huila District of Angola. It is easily distinguished by the presence of stipules. The petioles show interesting variation, being notably longer (up to 5 mm.) where they subtend branches. The standard is yellow (sometimes suffused reddish purple) and the petals are marked in a manner comparable to *C. orientalis* and *C. virgultalis*.

The material examined is cited below by provinces or districts and then by degree squares (first two digits degree south, second two digits degree east). We are grateful to the Directors of the National Herbarium, Pretoria, and the Botanical Garden and Museum of the University of Zürich for the loan of specimens. We have not thought it necessary to borrow all the material from Pretoria and we are grateful to Dr. Leistner for sending or commenting on the more critical specimens.

Key to *C. virgultalis* and allies

Stipules present; petioles 0-5 mm. long, distinctly longer on leaves subtending branches 1. *C. pseudovirgultalis*

Stipules absent:

Petioles mostly 6-18 mm. long; pedicels 6-9 mm. long in flower; branches glabrous or nearly so except on youngest parts; standard usually white inside and yellow lined reddish brown outside. 2. *C. orientalis*

Pods glabrous or soon glabrescent (ovary glabrous to densely pubescent); standard glabrous to sparsely pubescent; leaflets mostly 0,8-2,5 mm. wide a. subsp. *orientalis*

Pods persistently pubescent; standard extensively pubescent outside; leaflets usually mostly 2-9 mm. wide

b. subsp. *allenii*

Petioles 1-6 (-8) mm. long; pedicels 3-6 (-7) mm. long in flower; branches persistently finely pubescent:

Standard usually white, veined reddish brown or purple; keel 13-16 mm. long, usually reddish purple at tip; leaflets usually mostly (1,5-) 2,5-4 mm. wide

3. C. virgultalis

Standard usually bright yellow, unmarked; keel 11-14 mm. long, usually unmarked; leaflets often 0,8-2,5 mm. wide

4. C. spartioides

1. C. pseudovirgultalis Torre in Mem. Junta Invest. Ultram., sér. 2, 19: 25, t. 3 (1960) & Conspect. Fl. Angol. 3: 32 (1962).

Angola

Huila. 1413: 12 km. Jau-Humpata, TORRE 8637 (LISC, holotype (not seen); BM, isotype); Jau, SANTOS 722 (K).

2. C. orientalis Burt Davy ex Verdoorn in Bothalia 2: 417 (1928); Burt Davy, Man. Fl. Pl. & Ferns Transvaal: 401 (1932); Schreiber in Mitt. Bot. München 2: 289 (1957) & in Prodr. Fl. Südwestafrika 60: 25 (1970).

C. spartioides sensu auct. non DC.: Bentham in Hook., Lond. Jour. Bot. 2: 561 (1843), pro parte; Harvey in Fl. Cap. 2: 41 (1862), pro parte; Baker fil. in Jour. Linn. Soc., Bot. 42: 270 (1914), pro parte.

a. ssp. orientalis

Botswana

SE. 2425: 19 km. Molepolole - Letlaking, WILD 4953 (K, M); 97 km. Lobatsi - Ghanzi, LAMBRECHT 337 (K); 32 km. W of Kanye, LEACH & NOEL 207 (K, LISC); Kanye, HILLARY & ROBERTSON 627 (PRE).

South West Africa

OTJ. 2017: Waterberg, VOLK 1063 (M).

South Africa

Transvaal. 2327: 5 km. N. of Ons Hoop, CODD 8462 (K). 2526: Zeerust, HUTCHINSON 2959 (BM, K) & THODE A. 1381 (K, PRE); Matebe valley, HOLUB s.n. (K). 2527: Magaliesberg, BURKE s.n. (BM). Orange Free State. 2727: Rhenoster R., BURKE 338 (K,

lectotype; BM isotype) & ZEYHER 370 (BM, K, OXF, P).
Cape Province. 2625: Madibi - Setlagoli, DUPARQUET 469 (P).

b. ssp. allenii (Verdoorn) Polhill & Schreiber, stat. nov.

C. allenii Verdoorn in *Bothalia* 2: 417 (1928).

R h o d e s i a

W. 1725: Victoria Falls, ALLEN 226 (K, lectotype). 1827: Wankie Game Reserve, Gwaai Corridor, WILD 4723 (COI, K, L, LISC). 1828: Charama Plateau, BINGHAM 175 (K, LISC). 1928: Gwampa Forest Reserve, GOLDSMITH 83/56 (K, LISC) & 119/55 (K, LISC); Nyamandhlova Pasture Research Station, PLOWES 1751 (K, LISC). 2028: Bulawayo, F.A. ROGERS 13812 (K).

S o u t h W e s t A f r i c a

GRN. 1819: NE. of Karakuise, Cigarette, MAGUIRE 2390 (PRE).

S o u t h A f r i c a

Transvaal. 2327/2328: Ellisras - Vaalwater, WERDERMANN & OBERDIEK 1804 (K). 2428: 8 km. Vaalwater - Hermansdoorns, MEEUSE 10521 (M). 2527: Kroondal, LOUW 2594 (PRE).

3. *C. virgultalis* Burch. ex DC., Prodr. 2: 128 (1825); Bentham in Hook., Lond. Jour. Bot. 2: 561 (1843); Harvey in Fl. Cap. 2: 40 (1862); Baker fil. in Jour. Linn. Soc., Bot. 42: 269 (1914), pro parte; Verdoorn in *Bothalia* 2: 416 (1928), pro parte majore; Burt Davy, Man. Fl. Pl. & Ferns Transvaal: 401 (1932), pro parte; Schreiber in Prodr. Fl. Südwestafrika 60: 28 (1970), pro parte.

S o u t h W e s t A f r i c a

LUS. 2816. Orange R., Oabigarub, SCHENCK 242 (Z). 2816/2817: Orange R., Arisdriest, SCHENCK 265 (Z). KEE. 2619: 30 km WNW. of Aroab, ACOCKS 15585 (K) - not typical; 11 km. W of Aroab, DE WINTER 3377 (K, M) - not typical; Farm Kamelhaar, BLEISSNER 291 (M). 2719: Farm Orion, GIESS, VOLK & BLEISSNER 7201 (M). WAR. 2718: Gründorn, DINTER 5040 (BOL, K, Z). 2818/2819: Warmbad - Blydeverwacht, FLECK 445 (Z); Orange R., FLECK 446 (Z).

South Africa

Cape. 2820: Augrabies, MIDDLEMOST s.n. (BOL). 2822: Dunmurry WILMAN in BOLUS 2279 (BOL); Witsand, ESTERHUYSEN in BOLUS 2262 (BOL); 2822: 34 km. WSW. of Olifantshoek, LEISTNER & JOYNT 2798 (K, M). 2823: Dinas Rus to Clifton Oos, LEISTNER 1364 (K, M); Zandbult, LEISTNER 1552 (K, M). 2824: between Vaal and Riet Rivers, BURCHELL 1752 (G-DC, holotype; K, P, isotypes). 2919: Augrabies (Ougrabies) to Aggeneis (Aggenys), PEARSON 2928 (BM, BOL, K) - not typical. 2921: 24 km. NW. of Kenhardt, THERON 1944 (BOL, K). 2922: Prieska, BRYANT 356 (K); Kranskop, ACOCKS 2006 (K, M). 2923: Vaal R. flats, BOWKER 19 (K). ? : Namaqualand, PEARSON 7753 (BM, K) & WYLEY s.n. (K).

Intermediates between *C. virgultalis* and *C. spartioides*

South West Africa

MAL. 2517: Farm Huams, GIESS, VOLK & BLEISSNER 5558 (M). BET 2617: Sandverhaar, ENGLER 6695 (K), DINTER 4207 (BM, Z), PEARSON 3712 (BM, BOL, K) & POLE EVANS H. 19357 (PRE). 2717: Inachab, DINTER 1146 (Z). KEE. 2619: Wildheim Ost, LEISTNER 1790 (K, M); 8 km N. of Aroab (K, M).

South Africa

Cape. 2620: Kalahari Gemsbok National Park, near Groot Skrijpan, LEISTNER 1482 (K, M); 13 km. NW. of Tweendabbas Pan, LEISTNER 1478 (K, M). 2722: 8 km. S. of Sonstraal, LEISTNER 2091 (K, M); 8 km. N. of Faansgrove, LEISTNER 1600 (K, M). 2816: near Orange R., Verleptpram, DREGE, s.n. (BM, BOL, K, OXF, P). 2821: near Upington, "The Halt", GLOVER in BOLUS 10423 (BOL).

4. *C. spartioides* DC., Prodr. 2: 128 (1825); Bentham in Hook., Lond. Jour. Bot. 2: 561 (1843), pro parte; Harvey in Fl. Cap. 2: 40 (1862), pro parte; Baker fil. in Jour. Linn. Soc., Bot. 42: 270 (1914), pro parte; Verdoorn in Bothalia 2: 417 (1928).

C. virgultalis sensu auct. non Burch. ex DC.: Baker fil. in Jour. Linn. Soc., Bot. 42: 269 (1914), pro parte; Schreiber in Prodr. Fl. Südwestafrika 60: 28 (1970), pro parte.

B o t s w a n a

SW. 2122: 48 km. Ghanzi - Lobatse road, R. C. & D. C. BROWN 8293 (K). 2322: 43 km. Kan-Ghanzi, DE WINTER 7362 (K, M). 2421: 5 km NW. of Hukuntsi, BLAIR, RAINS & JALALA 2 (K). SE. 2126: near Malichwae, LUGARD 232 (K).

S o u t h W e s t A f r i c a

GO. 2218: Gobabis, WERNDORFF s.n. (M) - sterile; Breitenberg, SEYDEL 2507 (BR, K, M). 2219: Babi-babi, WILMAN in BOLUS 15339 (BOL). 2318: Farm Donnersberg, WALTER 2696 (M); Sania, STORY 5922 (K, PRE); Farm Onreg, MERXMÜLLER 1119 (K, M). SW/WIN. 22/14 - 17: Windhoek, Walfishbay, ESDAILE in ROGERS 15353 (K). WIN. 2217: 5, 6 km. W. of Omitara, CODD 5823 (K, L); Nosob, FLECK 259 (Z). REH. 2317: Rehoboth, BASSON 21 (PRE) & FLECK 451 (Z); Gravenstein, VOLK 11542 (M). 2318: Farm Reußenland, WALTER 2638 (M). GIB. 2417: Mariental, KEET 1511 (PRE). BET. 2617: Farm Sandverhaar, U. MEYER 40 (M). LUS. 2616: N. of Aus, VOLK 12817 (M) - poor specimen. KEE. 2619: Farm Brakpan, GIESS, VOLK & BLEISSNER 7232 (M) - not typical.

S o u t h A f r i c a

Cape. 2520: Kalahari Gemsbok National Park, Sewepanne, BARNARD 718 (PRE); Auob R., STORY 5603 (K); without exact locality, BRYNARD 413 (PRE). 2524: 98 km. W. of Mafeking, ACOCKS 18763 (K, M). 2620: Kalahari Gemsbok National Park, 24 km.N. of Geisemap Pan, LEISTNER 995 (K, M). 2622: Royena Halt to Sand Station, BURCHELL 2407 (K). 2623: Chooi Desert, BURCHELL 2336 (G-DC, holotype; K, L, M, P, isotypes). 2624: Farm Palmyra, RODIN 3663 (K). 2721: 13 km. E. of Tellery Pan, LEISTNER 2172 (K, M); 8 km. SW. of Kgop Pan, LEISTNER 2194 (K, M) - atypical. 2722: 8 km. S. of Lang Pan, LEISTNER 2074 (K, M); Klapin, LEISTNER 2051 (K, M).

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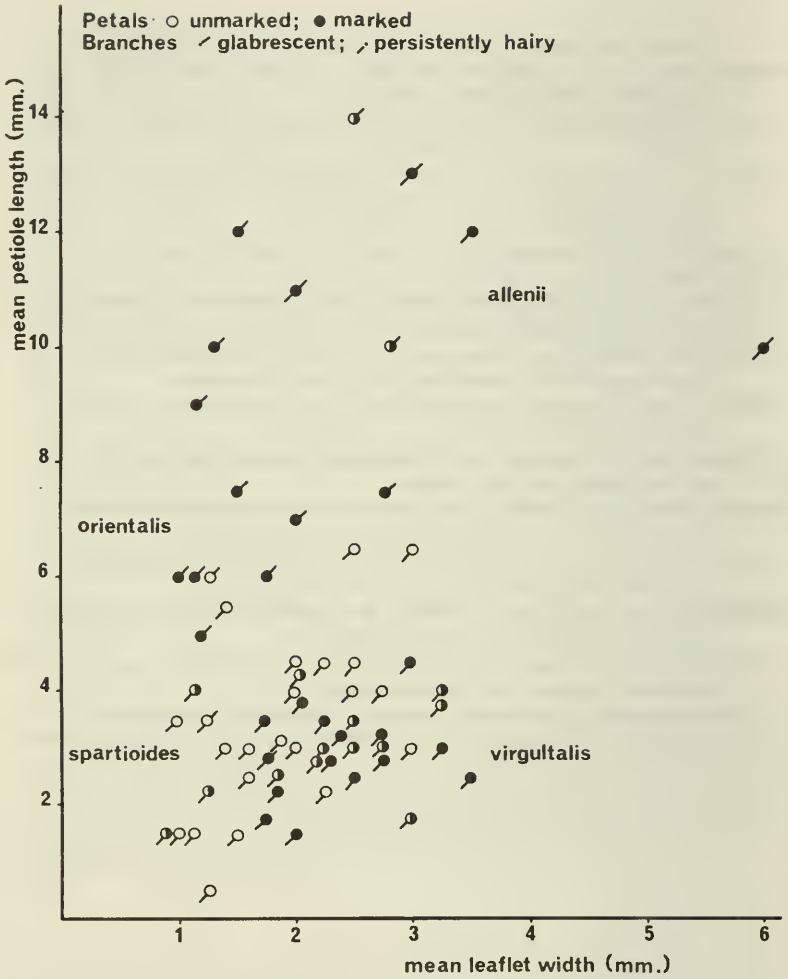
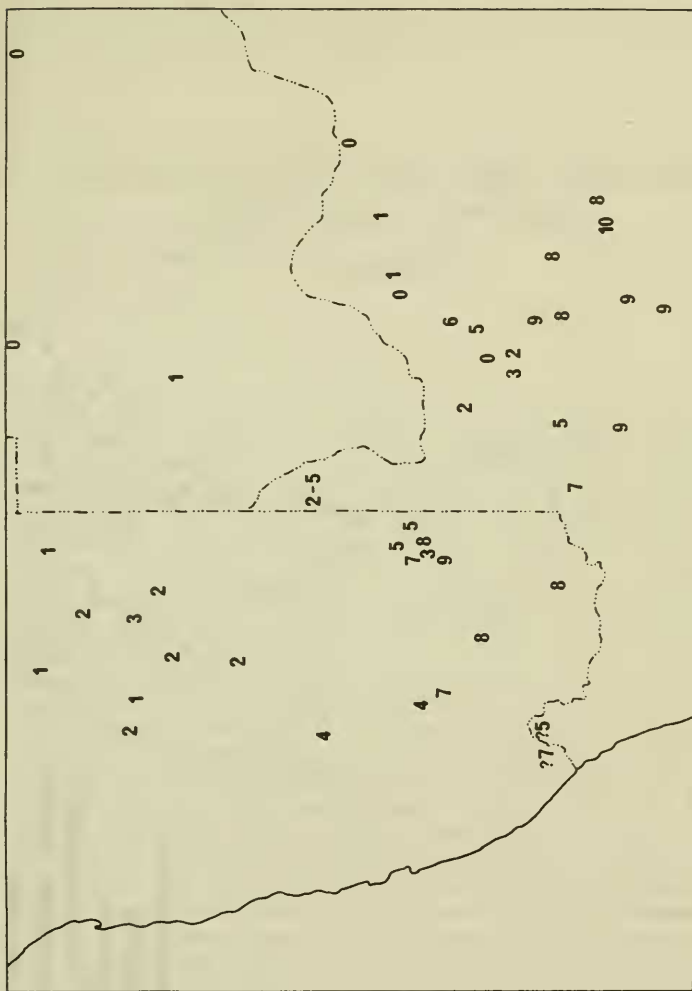
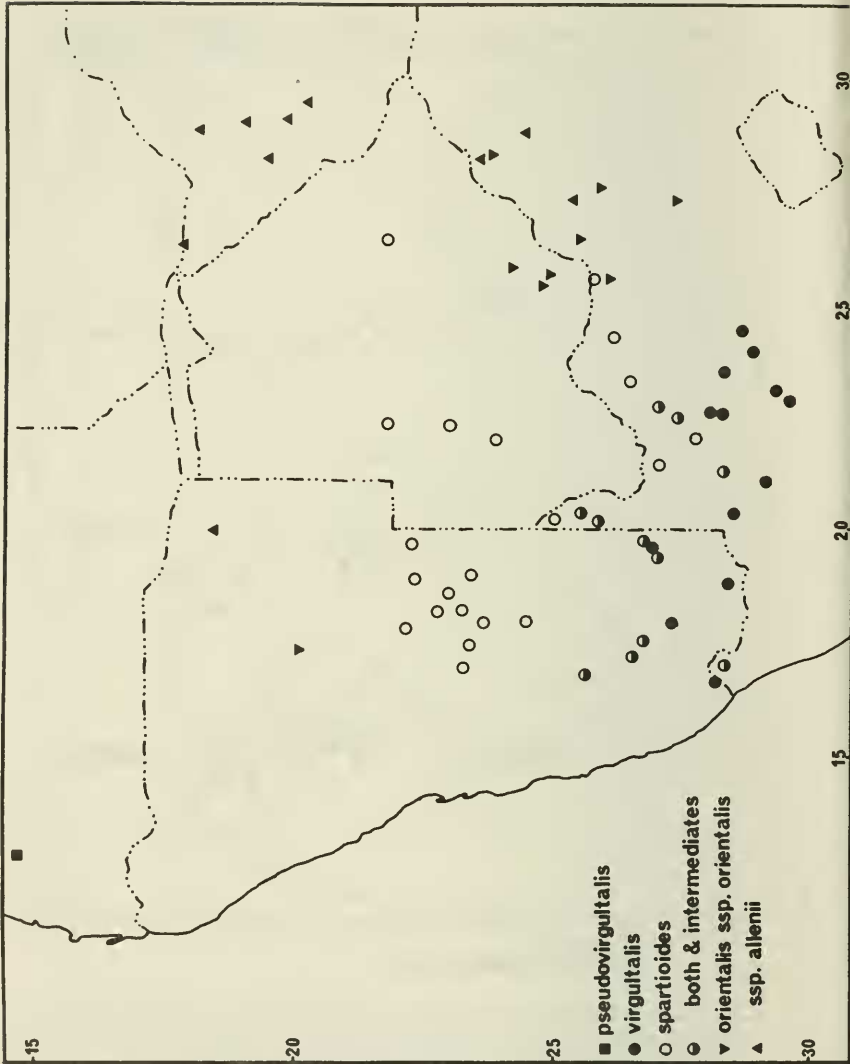


Fig. 1: Scatter diagram showing variation of mean petiole length and leaf width and relationship to flower petal markings and branch indumentum in *Crotalaria virgultalis* and allies.



Map 1: Hybrid index scores for *Crotalaria virgatalis* and *C. spartioides*.



Map 2: Distribution of *Crotalaria virgultalis* and allies.